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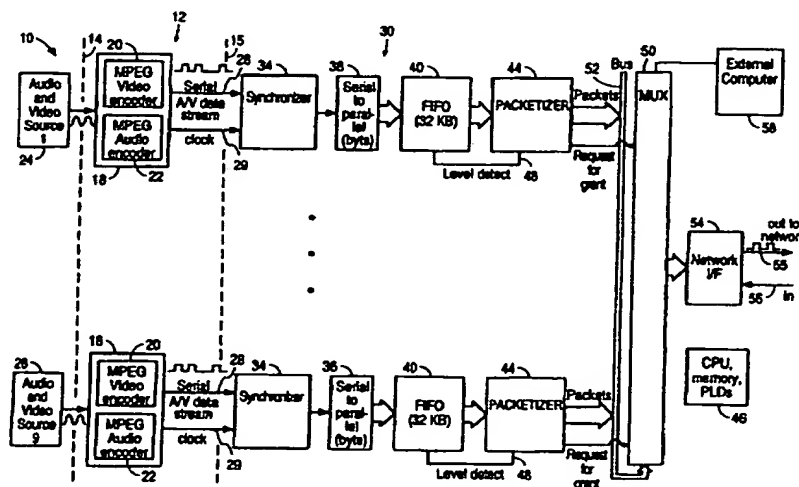
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(54) Title: DYNAMIC RATE CONTROL TECHNIQUE FOR VIDEO MULTIPLEXER



## (57) Abstract

A video multiplexer (50) is disclosed which incorporates a dynamic rate control feature. MPEG encoded video signals for each channel are stored in a first-in first-out (FIFO) buffer (40). A packetizer (44) for each channel detects the level in the FIFO buffer (40) and issues a request signal to the video multiplexer (50) that the channel desires to transmit the video signals on the network. The bandwidth allocation for a channel is either preselected by the video provider or automatically selected, and tokens are issued by a counter associated with each channel to give greater network access to those channels which require a higher bandwidth. A token multiplexer detects the bandwidth needs of the various channels by detecting the rate that the FIFO buffer is being filled and automatically multiplies the number of consecutive packets which the packetizer may transmit over the multiplexer during a single grant.

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## DYNAMIC RATE CONTROL TECHNIQUE FOR VIDEO MULTIPLEXER

FIELD OF THE INVENTION

5        This invention relates to video multiplexers and, in particular, to a technique for allocating bandwidths to video channels connected to the multiplexer.

BACKGROUND OF THE INVENTION

10        A time division multiple access (TDMA) multiplexer for video signals has as its inputs a plurality of video channels and is controlled to output only one channel at a time at an output port. One use of such a video multiplexer which will become increasingly more  
15 popular is in the area of video on-demand. The video provider supplies a different video program on each channel, encodes each video program in accordance with an accepted compression standard (e.g., an MPEG standard), and then multiplexes all the video channels  
20 on a single network cable, which may be an electrical conductor or a fiber optic cable. In video on-demand, one of the plurality of video programs multiplexed on the communications network is selected by the customer, and this video selection is then demultiplexed and  
25 displayed on the customer's television set.

Other uses of video multiplexers exist. Existing video multiplexers have various drawbacks. One drawback is that these video multiplexers are relatively expensive, for example over five thousand  
30 dollars for a particular four-port multiplexer.

In one prior art multiplexer, each video channel provides raw MPEG encoded video signals to the input of the multiplexer. The multiplexer polls each channel in sequence to determine whether the channel is ready to  
35 transmit its video data over the network. When a channel is granted access to the network, the multiplexer then synchronizes and packetizes the video

signals for that channel in accordance with a certain protocol and applies the packet to a network interface. The network interface modulates the data in the packet and places the packet in the proper form for being  
5 transmitted on the network. Such a prior art multiplexer is sometimes referred to as an asynchronous transfer mode (ATM) switch. Such an ATM switch has a fixed number of ports, is difficult to expand for additional ports, is expensive, and a single ATM switch  
10 is not compatible with a variety of types of networks due to the bandwidth limitations of either the ATM switch or the network.

An additional drawback of the prior art video multiplexers is that the bandwidth allocated for each  
15 channel is either fixed or not dynamically controllable to allow adjustment for high bandwidth channels. Further, the polling of each channel adds overhead to the system which delays its responsiveness to the changing needs of the various channels.

20 What is needed is a more economical multiplexer that is flexible enough to be used with virtually any network and is responsive to the changing needs of the various channels.

## 25 SUMMARY

A video multiplexer is disclosed which incorporates a dynamic rate control feature. MPEG encoded video signals for each channel are stored in a first-in first-out (FIFO) buffer. A packetizer for  
30 each channel detects the level in the FIFO buffer and issues a request signal to the video multiplexer that the channel desires to transmit the video signals on the network.

In the preferred embodiment, the bandwidth  
35 allocation for a channel is either preselected by the video provider or automatically selected, and tokens

are issued by a counter associated with each channel to give greater network access to those channels which require a higher bandwidth. A variable token bucket for each channel stores the issued tokens until needed.

5 A token multiplier detects the bandwidth needs of the various channels by detecting the rates that the FIFO buffers are being filled and automatically multiplies the number of accumulated tokens for the appropriate channels. The number of accumulated tokens are related  
10 to the number of consecutive packets which the packetizer may transmit over the multiplexer during a single grant.

By not polling the various channels, but instead sending grants to packetizers with tokens, there is  
15 less overhead in the system.

A multiplexer board allows additional channels to be added to the board by plugging in daughter boards. The flexibility of adding channels and the variable rate control for each channel allows the same board to  
20 be used with a variety of networks having different bandwidth capacities. A network interface board, customized for a particular network, plugs into the main multiplexer board and modulates the packetized data for transmission on the network.

25

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates the main functional blocks of the multiplexer board and the encoder board of the preferred video processing system.

30 Fig. 2 illustrates additional functional details of the multiplexer pertaining to the dynamic rate control feature.

Fig. 3 is a flowchart illustrating the process performed by the multiplexer.

35 Fig. 4 illustrates additional detail of the packetizer for each channel.

Fig. 5 illustrates the modularity of the video processor and the multiplexer board which allows the same multiplexer board to be used with a variety of communication networks.

5

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 illustrates the pertinent portion of the video processor 10 which incorporates the present invention. The video processor 10 also includes  
10 circuitry which is not shown pertaining to mixing video sources, providing special effects, providing alarms and redundant circuitry in the event of failures, and other circuitry which is optional and may be conventional.

15 In a preferred embodiment, the video processor 10 is housed in a cabinet into which is inserted a plurality of boards which are interconnected via conventional board sockets and buses. An encoder board 12, partitioned by dashed lines 14 and 15, contains the  
20 MPEG encoder engines 18. These encoder engines 18 are commercially available and, in the preferred embodiment, are C-Cube video RISC processors using a commercially available encoder program. The encoders 18 include an MPEG video encoder 20, for converting the  
25 incoming video signals into an MPEG-2 format, or other desired format, and an MPEG audio encoder 22, for converting the incoming audio portion of the signal into a conventional AES/EBU or MPEG-1 layer 2 format. These processors and formats are well known. Other  
30 formats may be employed, depending upon the application and the country in which processor 10 is used.

An audio and video source 24 is connected to channel 1, and a different audio and video source 26 is connected to channel 9. Other audio and video sources  
35 may be connected to channels 2-8. The video processor 10 may be expanded to process additional audio/video

channels. The video input signals may be NTSC, PAL, SVIDEO, or YCrCb analog signals, or digital video signals.

5 A video input/output circuit, contained within encoders 18, performs any required filtering and digitizing of the incoming video signal into a YUV format for processing by the MPEG encoder 20.

The output of the encoder board 12 is a serial audio/video datastream 28 along with a bit clock 29. 10 As is conventional, the audio data is time-stamped to enable the audio signals to ultimately be synchronized with the video signals.

The present invention is found in the multiplexer board 30.

15 The A/V datastream 28 and clock 29 are applied to a synchronizer 34. Synchronizer 34 looks for MPEG program or transport stream synchronization patterns (i.e., a predetermined combination of bits) which signal the beginning of a frame of data or other event. 20 In response, synchronizer 34 byte-aligns the incoming data stream. This prevents data being converted incorrectly from serial to parallel. Synchronizer 34 may also issue synchronizing signals, as needed, to the control circuitry controlling the various function 25 elements to signal that a new frame has begun.

The serial A/V datastream 28 is converted into 8-bit bytes by a serial-to-parallel converter 36 using conventional techniques. The bytes are then loaded into a first-in first-out (FIFO) buffer 40 which, in a 30 preferred embodiment, has a 32 KB capacity.

The synchronizer 34, serial-to-parallel converter 36, and FIFO buffer 40 are synchronized by the same clock source derived from clock 29.

35 The FIFO buffers 40 for the various channels fill up at different rates due to the nature of the MPEG encoding. The MPEG encoding basically reflects only

the changes between consecutive video frames. Accordingly, a minimum number of information bits are generated by encoder 18 for a frame which has not changed since the previous frame. Conversely, a large number of information bits must be generated during a frame period by encoder 18 to reflect a large change between consecutive frames, such as would occur in an action sequence in a video program. Accordingly, the bytes applied to the input of FIFO buffer 40 are bursty and unpredictable.

A packetizer 44 addresses the bytes in FIFO buffer 40 and generates packets of data containing not only the audio/video information (the payload) but control and overhead information in accordance with a predetermined protocol. Such control and overhead information include CRC bits, frame identification bits, synchronization bits, source and destination address bits, channel ID bits, sequence bits, time-stamps, and other header information which is called for by the protocol. In one embodiment, the protocol is the AAL5 format for asynchronous transfer mode (ATM) packets. Those skilled in the art of digital communications will understand the various protocols for various networks. Additional details regarding the packetizer will be described later with respect to Fig. 4.

Control and memory circuitry, such as a ROM, RAM, PLD, and CPU, for controlling the overall function of the multiplexer board 30 and the various functional blocks are shown in block 46.

In a first embodiment of the invention, packetizer 44 senses the fill level in FIFO buffer 40 to determine whether there is enough data in FIFO buffer 40 to create a single packet. In one embodiment, packetizer 44 fetches raw MPEG-2 program stream or transport stream data from FIFO buffer 40 when there is enough



data for a single 48 byte A/V payload. To detect that such a threshold has been reached, a flag is set when byte number 48 is stored in FIFO buffer 40. This may be accomplished by comparing the byte address to the  
5 threshold address. When this flag is triggered, a signal is detected on line 48 by packetizer 44.

Once this threshold is detected, the packetizer 44 then issues a request for grant to multiplexer 50, which is actually an arbiter for determining access to  
10 a common bus 52. Multiplexer 50 then grants the request for access to bus 52. In one embodiment, if more than one request for grant is received at the same time, then priority is given in the channel order.

Once a multiplexer 50 grants a request to a  
15 packetizer 44, the packetizer 44 retrieves a payload of data from FIFO buffer 40, appends a header obtained from a dual port RAM, calculates the CRC code, and obtains other information needed for the packet in the AAL5 protocol. The packetizer 44 supplies the bytes,  
20 as they are being generated, to the common bus 52. The parallel bits on bus 52 are then converted into a serial stream and modulated into the required signals for transmission on the external communications network. Such modulating and other necessary  
25 processing is performed by the network interface (I/F) 54 which, in the preferred embodiment, is a plug-in module. Network I/F 54 may convert the electrical signals into optical signals for connection to an optical cable 55 in a SONET system or apply the  
30 modulated serial bit stream to a conductive cable on any network (e.g., STS-3). The optical SONET network has a bandwidth of 155 MHz. The network may also provide control signals to processor 10 via cable 56.

The packetizer 44 will typically require several  
35 grants from multiplexer 50 before being able to transmit an entire frame of A/V data over bus 52.

Issuing requests for grant rather than waiting for the multiplexer 50 (or arbiter) to poll the packetizers results in a time savings and memory savings in that the packetizers 44 do not have to wait to be polled before being issued access to bus 52. Thus, channels which are not generating data or which are generating data very slowly do not delay bus access to a19

packetizer which needs access to bus 52. The structure shown in Fig. 1 is also very economical as compared to prior art video processors in that the packetizing is performed by each channel prior to being multiplexed. In certain prior art structures, an ATM switch receives the raw MPEG data, multiplexes the data and packetizes the data. Such a prior art ATM switch is more expensive than the multiplexing circuitry shown in Fig. 1 since multiplexer 50 does not have to be synchronized with the MPEG data in the various channels and thus results in a simpler system. Additionally, the system of Fig. 1 allows for customized or automatic bandwidth allocation to the various channels as described below.

#### Description of Dynamic Rate Control

While using the system of Fig. 1, it is expected that certain video sources will consistently require more bandwidth than other video sources. This may be the case where one video source (e.g., channel 9) is a sports program while another video source (e.g., channel 1) is a non-action drama. Therefore, although the packetizers 44 for channels 1 and 9 may both request access to bus 52, FIFO buffer 40 for channel 9 is filling up faster than FIFO buffer 40 for channel 1. It is desirable to empty FIFO buffer 40 in channel 9 at a faster rate to prevent FIFO buffer 40 from overflowing. In such a case, using the present system, more bandwidth may be allocated to channel 9 than

allocated to channel 1. For example, channel 1 may be allocated a maximum bandwidth of 3 MHz while channel 9 is allocated a maximum bandwidth of 10 MHz.

In the preferred embodiment, packetizer 44 can  
5 packetize bytes from FIFO buffer 40 at a rate six times the rate that bytes are being stored in FIFO buffer 40. Thus, FIFO buffers 40 may be emptied relatively quickly once a request for grant is accepted. FIFO buffers 40 can only be accessed by packetizers 44 between the  
10 loading of bytes by the serial-to-parallel converters 36.

To allocate different bandwidths to each channel at any time, a controller, using an external personal computer 58, selects the bandwidths for each of the  
15 channels. This bandwidth allocation is performed using the functional blocks shown in Fig. 2.

Multiplexer 50 contains a counter 62 for each channel. In a preferred embodiment, counters 62 are 12-bit counters. If all channels were to be given an  
20 equal bandwidth allocation, then all counters 62 would be programmed by computer 58 to have the same modulus. A channel which is to be given a higher bandwidth allocation is programmed to have a lower modulus than the counters associated with channels with a lower  
25 bandwidth allocation. Once the counters are initially programmed, a register stores this program until changed by the external computer 58.

A byte clock is applied to each of the counters 62. The byte clock is obtained from the same clock  
30 which clocks packetizers 44. When a counter 62 counts down from its highest value to 0, the counter 62 issues a token for that channel to an arbiter 66. Arbiter 66 only grants a channel access to bus 52 when there is both a token issued by the counter 62 and a request for  
35 grant by the packetizer 44 for that channel. Assuming the expected needed bandwidth for channel 1 is much

less than that needed for channel 9, the modulus in the channel 9 counter 62 may be preset to 256 to make the channel 9 counter have 256 states, while the modulus in the channel 1 counter 62 may be preset to 512 to make the channel 1 counter have 512 states. Thus, the counter 62 for channel 9 will issue tokens at twice the frequency as the counter 62 for channel 1. In turn, the packetizer 44 for channel 9 will be able to empty its FIFO buffer 40 at twice the rate that the packetizer 44 for channel 1 can empty its FIFO buffer 40.

A memory (a token bucket 68) used by arbiter 66 stores the tokens for a channel until used by the channel. Once a token is used, it is deleted from the token bucket 68. Thus, a single grant request can use up multiple tokens for transmitting multiple packets. The capacity of the token bucket 68 is programmable up to a maximum of 16, in one embodiment. Tokens issued by counter 62 after the token bucket 68 is full are discarded. Varying the capacity of the token bucket 68 as needed is another way to allocate bandwidth to each channel by selecting a maximum bus 52 access time for a channel.

The above-described bandwidth allocation may be performed dynamically as needed by the various channels. Thus, the use of these tokens and counters 62 sets a maximum bandwidth per channel, and its advantages are utilized when there is not enough total bandwidth in the video processor 10 or not enough buffer memory network to accommodate all the channels.

The setting of the modulus of a counter 62 may also be performed automatically by detecting the level of data in the FIFO buffer 40 and changing the modulus of the token counter 62 as necessary to ensure the FIFO buffer 40 does not overflow.

This dynamic bandwidth allocation is particularly useful in the preferred embodiment of the invention, which uses a motherboard for channels 1, 2, and 3 and is expandable to receive two daughter boards, each containing three additional channels. As more channels are added, the likelihood increases that the bandwidth requirements for one or more channels will exceed the bandwidth granted by multiplexer 50 to those channels unless more bandwidth is allocated to those channels.

10 In the preferred embodiment of the invention, an additional automatic bandwidth allocation circuit is incorporated into multiplexer 50. In this embodiment, threshold detectors are set at various address locations in FIFO buffers 40 for detecting the data level in FIFO buffers 40. For example, a detector may be set at the one-half full location in buffer 40, the three-quarters full location, and the one-packet full location. The detectors may be simple comparators which detect when a certain location in FIFO buffer 40 is addressed for storing a byte from the serial-to-parallel converter 36. In the preferred embodiment, there are both fixed detectors and movable detectors to provide default and customized bandwidth allocation.

25 If it is detected that the data in a FIFO buffer 40 exceeds a preset threshold, either over a period of time or after a number of occurrences, this signals that the packetizer 44 for that channel needs access to the common bus 52 at a greater rate. In response, a token multiplier 70 for that channel is automatically programmed to multiply the access time for the packetizer 44 for that channel. For example, if the token multiplier 70 for a high bandwidth channel were set to four, then for each access granted to the packetizer 44 (by the simultaneous occurrence of a request and a token) the access time would be multiplied by four to allow four consecutive packets to

be transmitted on bus 52. In one embodiment, the token multiplier can multiply access times two or four times. Since, in the preferred embodiment, a token bucket 68 can hold up to 16 tokens, a maximum bus 52 access time  
5 is 16 x 4, or 64 consecutive packets. In other embodiments, the maximum multiplier may be 16 or greater.

The multiplier value is dynamically adjusted as needed. For example, if it is seen by the threshold  
10 detector that the FIFO buffer 40 is 1/2 full, the token multiplier 70 would be programmed to double its multiplication for that channel until the data level in the FIFO buffer 40 is below the threshold level.

Accordingly, bandwidth allocation for each channel  
15 is determined automatically, or by a predetermined allocation, or a combination of both.

Fig. 3 is a flowchart illustrating this dynamic bandwidth allocation (or dynamic rate control) for any one of the channels. In step 1, the audio/video  
20 signals are stored in FIFO buffer 40.

In step 2, packetizer 44 detects the level of data in FIFO buffer 40. This level is also detected by the token multiplier circuit 70 in multiplexer 50 for setting the token multiplier.

25 In step 3, the packetizer 44 detects whether there is sufficient data in FIFO buffer 40 for generating a single packet. If there is not enough data, then the packetizer 44 waits until this initial level is reached.

30 In step 4, if there is sufficient data in FIFO buffer 40 to generate a packet, packetizer 44 requests a grant to use bus 52.

In step 5, which may occur at any time, the counter 62 for that particular channel is programmed to  
35 issue tokens at a predetermined frequency, depending on the channel's bandwidth allocation.

In step 6, it is now determined whether a token has also been issued for that channel requesting a grant. If no token has issued, the channel must wait until a token has been issued before access to bus 52 is granted.

In step 7, once there is both a request for grant and a token issued for that channel, a channel request is granted by the multiplexer 50. The length of time the channel is granted access to bus 52 depends upon the number of tokens in the token bucket 68 and the token multiplier setting for that channel. This token multiplier is determined in step 8 by detecting whether the level in FIFO buffer 40 is above a preset threshold for a period of time (including an instantaneous period). If it is determined in step 8 that the bandwidth allocation must be increased, the token will be effectively multiplied in step 9 so as to provide a longer access time to bus 52. Conversely, the token multiplier may reduce the access time if it is detected that the FIFO buffer 40 level is low.

Fig. 4 illustrates in greater detail the packetizer 44 for each channel. Packetizer 44 basically consists of counters which identify the bit positions in the various fields for the protocol and a state machine which calls on sources of data to build a packet. One skilled in the art would understand the function of packetizer 44 in Fig. 4.

Briefly, a signal is generated on line 80 when the data in FIFO buffer 40 has exceeded a predetermined threshold level, such as the data needed for a single packet. A state machine 82, which may be a programmable logic device or other logic circuit, controls the various functions of the packetizer 44 and is clocked by a bit clock (not shown). When packetizer 44 is to generate a packet, the state machine 82 addresses a dual port RAM 84 for the header

information. The header information is then applied to an input of multiplexer 86. The state machine 82 controls multiplexer 86 to output this header information to an 8-bit register 88, which then  
5 transfers the data onto the bus 52. State machine 82 also controls a checksum circuit 89 for generating checksum bits and supplying these bits to register 88 via multiplexer 86.

Counter 90 counts byte positions in a packet, and  
10 counter 91 counts bytes in a single frame or other multi-packet unit. The counters 90 and 91 are programmed for a particular ATM and AAL5 protocol and are used to signal the state machine 82 to access and transmit data. The RTP counter 92 generates a 16-bit  
15 sequence number used in the header for designating the sequence of packets in a frame.

The state machine 82 accesses the data in FIFO buffer 40 at the appropriate time by the read enable line 96, and this data is then transferred via parallel  
20 lines 98 to multiplexer 86. The state machine 82 controls multiplexer 86 to transfer this data to the register 88 and, in turn, to bus 52.

Additional data for transmission may be provided on a local bus via lines 100, and a local bus state  
25 machine 95 (incorporating control status registers) is controlled via a microprocessor (in block 46 in Fig. 1) to load data in RAM 84 and to control other aspects of packetizer 44. For example, the local bus may signal to the packetizer 44 that it should be deactivated  
30 after a frame is complete, or reset values in the packetizer 44.

Thus, the packetizer 44 fetches data from the FIFO buffer 40, appends ATM headers and trailers, and transmits the ATM data onto bus 52 until its access  
35 time or data has run out. In one embodiment, at the end of a group of packets, such as at the end of a



frame, the packetizer 44 will zero-fill the last ATM packet and fetch 4 bytes of AAL5 trailer information from the dual port RAM 84 and output a CRC-32 checksum that is calculated over the entire payload of the AAL5 packet. The program stream AAL5 frame length can be set up to 64K bytes by counter 91.

The request for grant signal is provided on line 104 while the granting of the channel by the multiplexer 50 is provided on line 106.

The ATM and AAL protocols may be found in GR-1113-CORE, Issue 1, July 1994, incorporated herein by reference.

#### Description of System Modularity

Fig. 5 illustrates the encoder board 12 and multiplexer board 30 while supported in a cabinet and interconnected by conventional card sockets and buses.

The dynamic rate control described herein enables the same multiplexer board 30 to be used for virtually any communications network 112, whether it is a high bandwidth optical network (e.g., SONET) or a lower bandwidth network using electrical conductors. The multiplexer board 30 can grow from three channels to six channels by the plugging in of a daughter board 114, containing channel circuitry identical to that shown in Fig. 1, and may be additionally increased to nine channels by plugging in a second daughter board 116.

A network interface (I/F) module 120 is designed for converting the packetized data into signals which may be directly connected to the communications network 112. A connector 122 connects the output signals of the network I/F module 120 to the network 112. Connector module 122 may be an optical interface or other connector.

Due to the various bandwidth capacities of the different communications networks 112 which may be connected to the video processor 10, the maximum bandwidths on the various channels may have to be limited to prevent bandwidth hogging of one or more of the channels, as previously mentioned. In the automatic bandwidth allocation mode, using the token multiplier 70 in Fig. 2, the bandwidth of the network is shared to an optimized extent by the various channels on an as-needed basis. However, if this automatic bandwidth allocation still results in not enough bandwidth to transfer all the video channels' data completely, then the operator of the video processor may intervene by using the external computer 58 (Fig. 1) to limit the upper magnitude of a token multiplier 70 or a token bucket 68 or change the programming of the counters 62 as necessary to optimized the use of the bandwidth of the communication network.

One skilled in the art after reading this disclosure would understand the circuitry and software necessary for implementing this invention.

Although the term packet has been used herein to describe a transmitted unit of data, other terms, such as a cell, are used in the field to be synonymous with a packet.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the appended claims are to encompass within their scope all such changes and modifications as fall within the true spirit and scope of this invention.

CLAIMS

What is claimed is:

1. A video processor having a plurality of channels, each channel for being connected to a video source, said video processor comprising:
  - 5 a storage buffer for each of said channels for receiving video data associated with a particular channel;
  - 10 a packetizer for each channel connected to receive video data from an associated storage buffer;
  - a bus connected to an output of each packetizer for receiving packets of data output from each packetizer;
  - 15 an arbiter for receiving grant requests from each of said packetizers to access said bus, each of said packetizers signalling a request for granting access to said bus when it is determined that said storage buffer contains an amount of
  - 20 data greater than a threshold amount; and
  - a means for allocating bandwidth on said bus which allows selected channels to have more access to said bus than other channels.

## AMENDED CLAIMS

[received by the International Bureau on 3 November 1997 (03.11.97);  
new claims 2-24 added; claim 1 unchanged (6pages)]

1. A video processor having a plurality of channels, each channel for being connected to a video source, said video processor comprising:

5 a storage buffer for each of said channels for receiving video data associated with a particular channel;

a packetizer for each channel connected to receive video data from an associated storage buffer;

10 a bus connected to an output of each packetizer for receiving packets of data output from each packetizer;

an arbiter for receiving grant requests from each of said packetizers to access said bus, each  
15 of said packetizers signalling a request for granting access to said bus when it is determined that said storage buffer contains an amount of data greater than a threshold amount; and

a means for allocating bandwidth on said bus  
20 which allows selected channels to have more access to said bus than other channels.

2. The processor of Claim 1 wherein said threshold amount is an amount of data needed to create  
25 a single packet.

3. The processor of Claim 1 wherein said storage buffer comprises a first-in first-out (FIFO) buffer.

30 4. The processor of Claim 1 wherein said means for allocating bandwidth comprises a controller which preselects an allocated bandwidth for each of said channels.

AMENDED SHEET (ARTICLE 19)

5. The processor of Claim 1 wherein said means for allocating bandwidth comprises a means for dynamically allocating bandwidth to each of said channels depending upon the bandwidth requirement for each of said channels.

6. The processor of Claim 1 wherein said means for allocating bandwidth comprises a token counter for each of said channels, each of said token counters having a modulus, each of said token counters when cycling through a predetermined state causing a token to be issued for its associated channel, said modulus being determined for each token counter based upon an allocated bandwidth for an associated channel.

7. The processor of Claim 6 wherein said predetermined state is a zero state for each of said counters.

8. The processor of Claim 6 wherein said arbiter only grants access to said bus when a packetizer for a channel requests access to said bus and a token has issued for that particular channel.

9. The processor of Claim 8 further comprising a token bucket memory for identifying an accumulated number of tokens issued by said token counter for each channel, a token being deleted from said token bucket memory when utilized by said packetizer.

**AMENDED SHEET (ARTICLE 19)**

10. The processor of Claim 9 wherein said token  
bucket memory limits a number of accumulated tokens to  
a selected number of tokens to limit a number of  
5 sequential packets which may be transmitted to said  
bus.

11. The processor of Claim 10 wherein a maximum  
number of tokens stored in each token bucket memory is  
10 programmable in order to selectively allocate bandwidth  
to each channel.

12. The processor of Claim 6 wherein each token  
represents a single packet which may be transmitted to  
15 said bus after a packetizer has requested access to  
said bus.

13. The processor of Claim 6 further comprising a  
token multiplier for each channel which multiplies a  
20 number of tokens accumulated for each channel to  
increase access time to said bus.

14. The processor of Claim 13 wherein said token  
multiplier is programmable to select a token  
25 multiplication factor.

15. The processor of Claim 6 further comprising  
at least one detector detecting an amount of data  
within said storage buffer for each channel, an amount  
30 of data in said storage buffer exceeding a certain

**AMENDED SHEET (ARTICLE 19)**

amount causing more tokens to be available for a particular channel to allow said packetizer to increase access to said bus.

5           16. The processor of Claim 15 wherein said at least one detector includes a detector sensing an amount of data needed to fill a complete packet as well as an additional detector detecting an amount of additional data.

10

          17. The processor of Claim 16 wherein, when said additional detector detects an amount of data in said storage buffer beyond a certain amount, said additional detector controls a token multiplier to multiply a  
15 number of tokens issued for a particular channel to provide additional bandwidth for that particular channel until such additional bandwidth is no longer needed.

20           18. The processor of Claim 1 wherein said video processor comprises a multiplexer board which receives additional boards containing circuitry for one or more channels, the number of channels being processed by said processor being determined by the number of  
25 additional boards plugged into said multiplexer board.

          19. The processor of Claim 18 further comprising a network interface module for converting packetized data into signals for connection to a communications

**AMENDED SHEET ( ARTICLE 19 )**

network, bandwidths for said channels being allocated to comply with a bandwidth of said network.

20. A method for transferring video data in a  
5 multi-channel system comprising:

receiving video data in a storage buffer  
for each channel;

detecting a level of data in said storage  
buffer;

10 determining whether said level in said  
storage buffer exceeds a certain threshold;

issuing tokens for each channel, wherein said  
tokens are generated based upon a bandwidth  
allocated to each channel; and

15 determining whether there simultaneously  
exists one or more tokens for a particular channel  
combined with a determination that said data in  
said storage buffer for a particular channel  
exceeds said certain threshold, and, if so,  
20 granting said particular channel access to a bus  
for transmission of said data.

21. The method of Claim 20 further comprising:

determining whether said data in said storage  
25 buffer has exceeded a second threshold and, if so,  
multiplying a number of tokens available for said  
channel, wherein the number of tokens relates to  
access time to said bus.

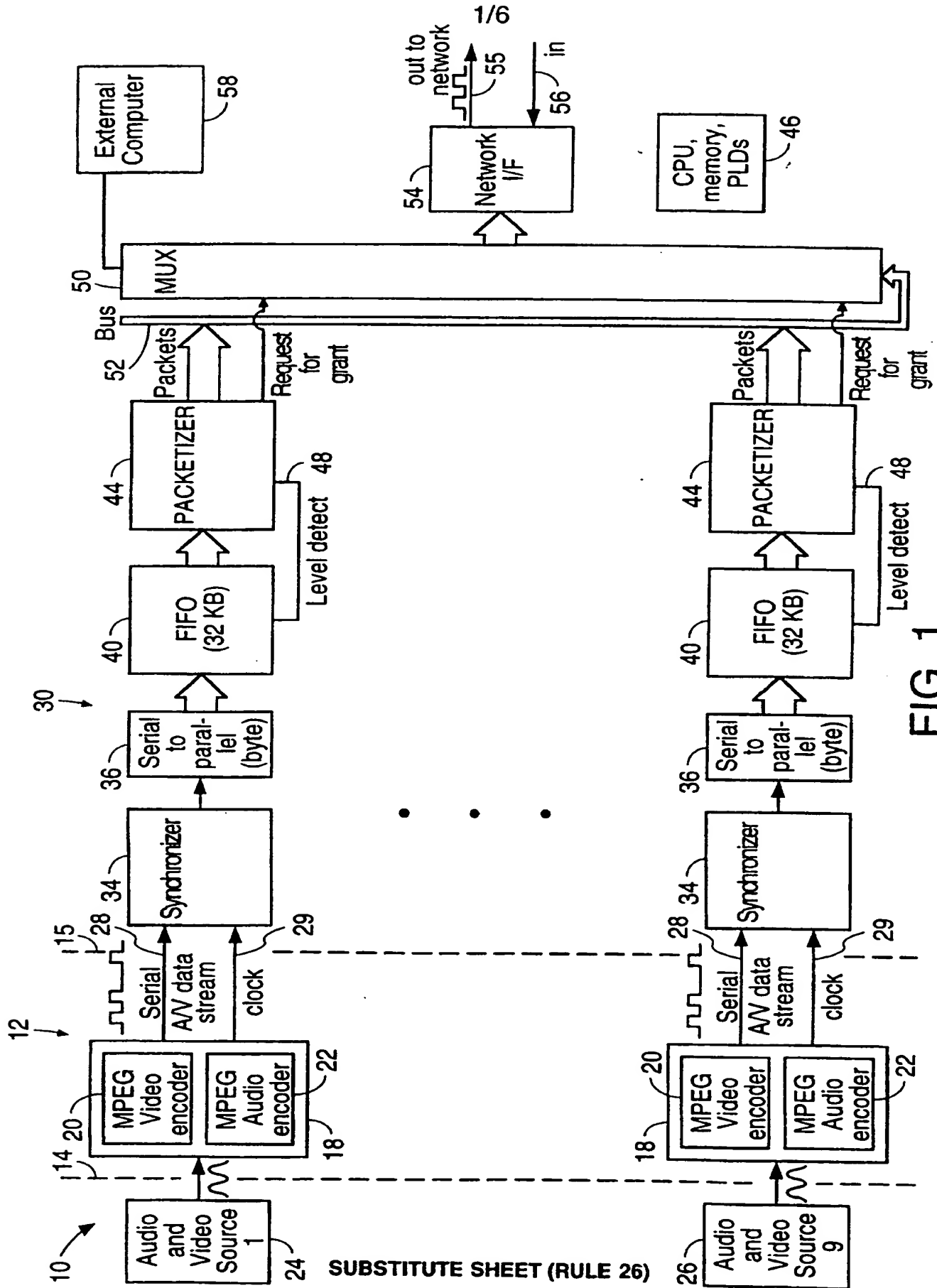
**AMENDED SHEET (ARTICLE 19)**



22. The method of Claim 20 wherein said tokens are generated by a counter associated with each channel, each said counter having a modulus, wherein a token is generated by each counter after sequencing  
5 through a predetermined state.

23. The method of Claim 22 wherein said tokens are accumulated in a token bucket memory until needed for transmission of said data in said storage buffer to  
10 said bus, a token being deleted from said token bucket memory after being utilized by said particular channel.

24. The method of Claim 20 wherein said data in said storage buffer is packetized prior to being  
15 transmitted to said bus.



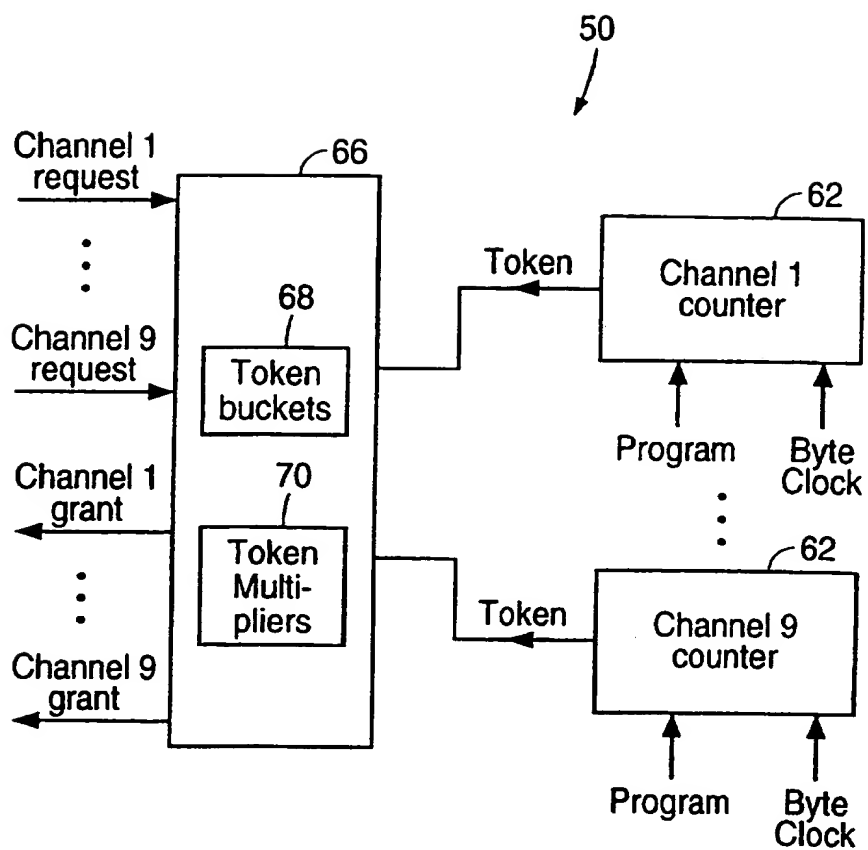


FIG. 2

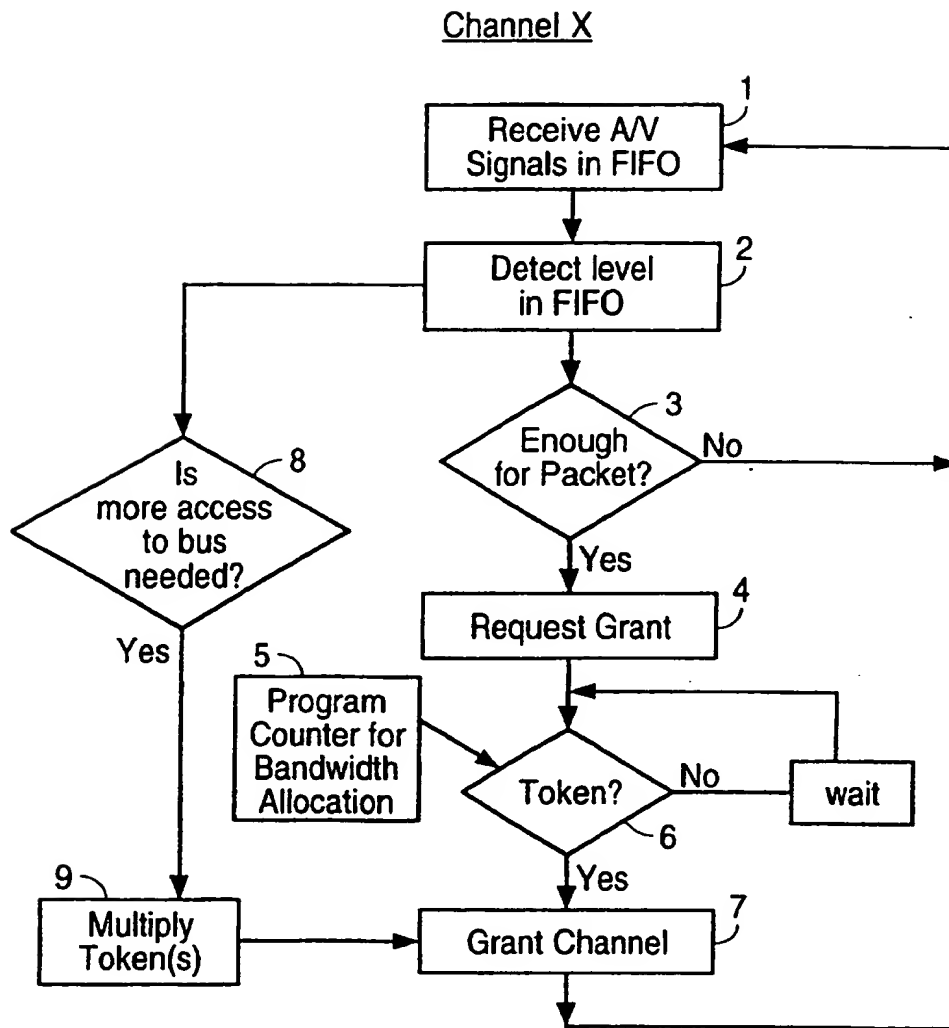
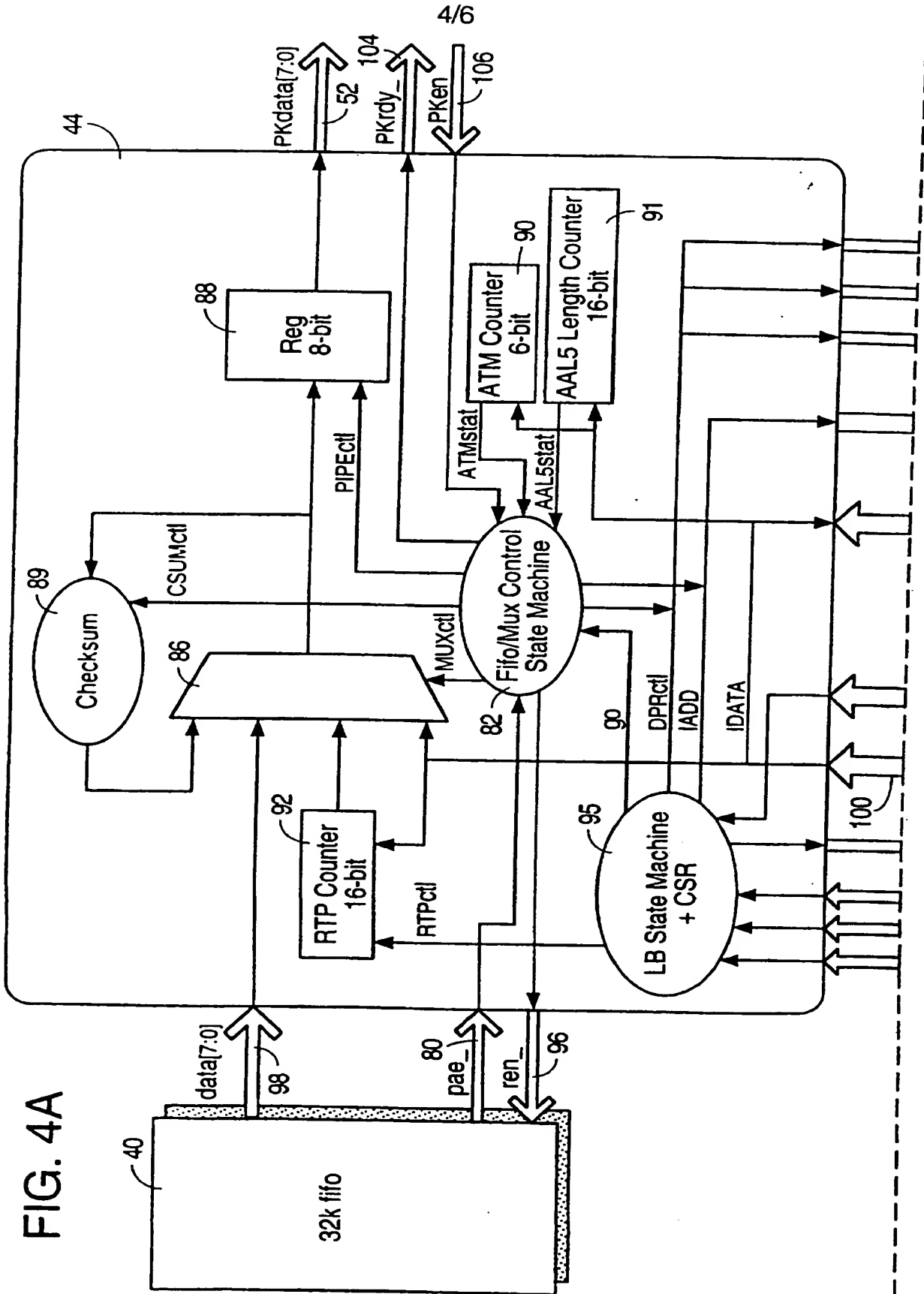


FIG. 3



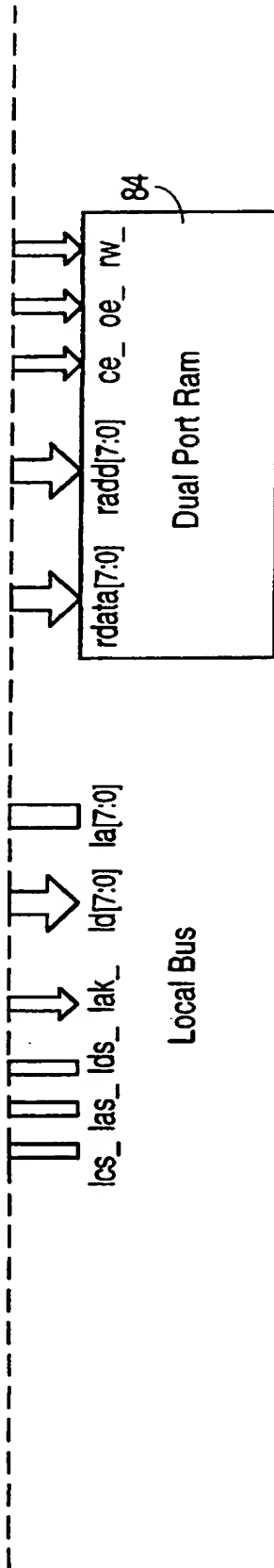


FIG. 4B

|         |         |
|---------|---------|
| FIG. 4A | FIG. 4B |
|---------|---------|

FIG. 4

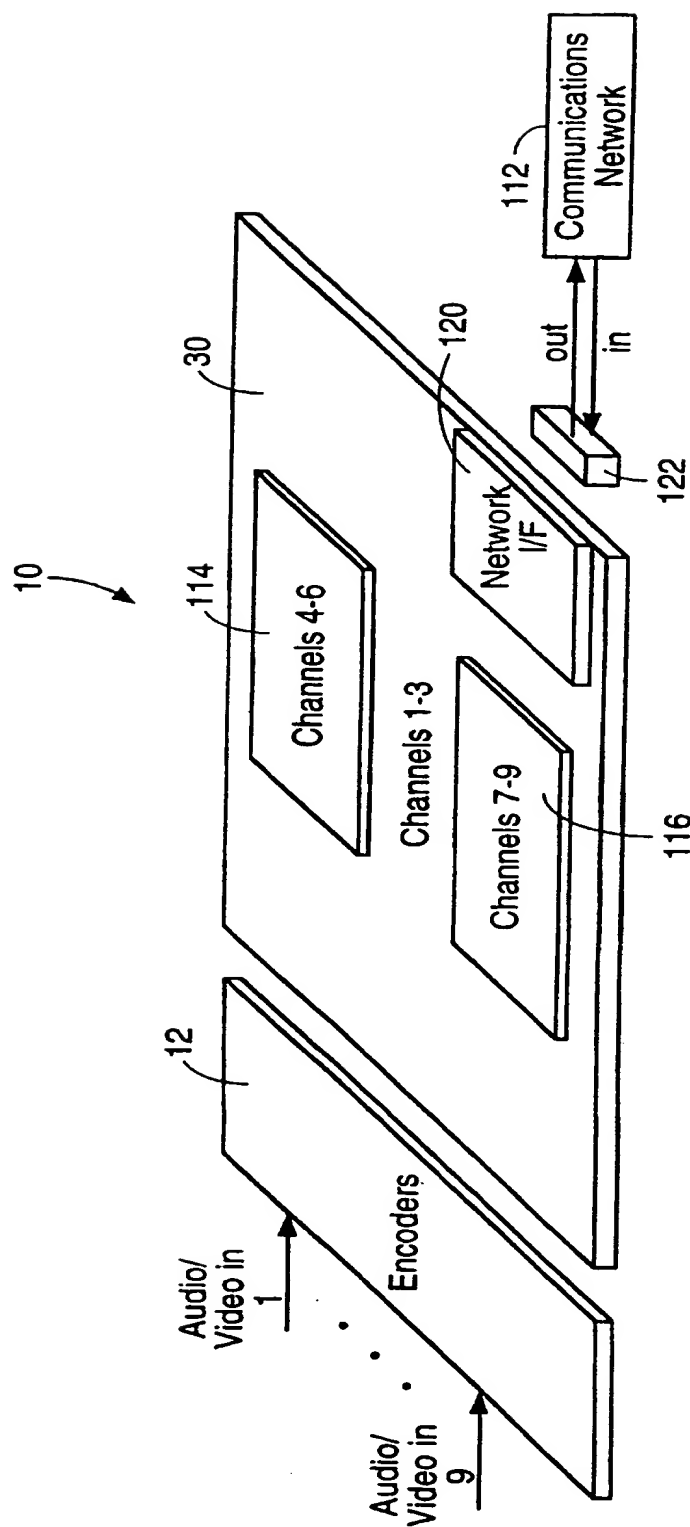


FIG. 5

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US97/09670

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : HO4N 7/10, 7/14, 7/12, 11/02

US CL : 348/12, 13, 10, 6, 388, 390

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. 348/12, 13, 10, 6, 388, 390

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS - channels, bandwidth allocation, packetizing, FIFO, buffers, mux, bit rate

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
|-----------|--|-----------------------|
| X,P       | US 5,600,573 A (HENDRICKS et al) 04 February 1997, fig. 1, fig. 3a, fig. 3b, col. 3, lines 16-67, col. 4, lines 1-67, col. 11, lines 24-67, col. 12 lines 1-31 | 1                     |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

|   |  |
|---|--|
| * Special categories of cited documents:  | "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention  |
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Date of the actual completion of the international search

04 AUGUST 1997

Date of mailing of the international search report

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